

REMARKS

The Office Action mailed February 27, 2007, has been received and reviewed. Claims 1 through 25 are currently pending in the application. Claims 1 through 25 stand rejected. Applicants respectfully request reconsideration of the application in view of the remarks set forth below.

35 U.S.C. § 102(b) Anticipation Rejections

Anticipation Rejection Based on U.S. Patent No. 6,465,352 to Aoki et al.

Claims 1 through 16, 20, 22, 24, and 25 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Aoki et al. (U.S. Patent No. 6,465,352). Applicants respectfully traverse this rejection, as hereinafter set forth.

A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. *Verdegaal Brothers v. Union Oil Co. of California*, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). The identical invention must be shown in as complete detail as is contained in the claim. *Richardson v. Suzuki Motor Co.*, 9 USPQ2d 1913, 1920 (Fed. Cir. 1989).

Applicants assert that independent claim 1 is not anticipated by Aoki et al. because Aoki et al. does not expressly or inherently describe “exposing at least a portion of the metallic layer to an oxidizing agent, the oxidizing agent causing an oxidation injury to the at least a portion of the metallic layer,” and “exposing the metallic layer to a reducing plasma to at least partly reverse the oxidation injury.”

In reference to Figures 7A-7F, Aoki et al. describes a method of removing a resist film and a deposition process after a dry-etching is carried out using the resist film as a mask in a semiconductor device fabricating process. *Aoki et al.*, column 1, lines 8-11. As shown in FIG. 7A, Aoki et al. describes a structure that includes copper film 3, a silicon nitride film 4, a hydrogen silsesquioxane (HSQ) film 5, and a resist film 6. *Id.* at column 8, lines 51-67. As shown in FIG. 7B, Aoki et al. describes dry-etching a through-hole 7 in the HSQ film 5 and the silicon nitride film 4 using an etching gas of mixed CHF₃ and Ar. *Id.* at column 9, lines 6-11. As seen in FIG. 7B, a portion of the copper film 3 is exposed in the through-hole 7. As also seen in FIG. 7B, an etching residue 8 and a resist surface hardened layer 9 on the resist film 6 are

formed during formation of the through-hole 7. *Id.* at column 9, lines 11-15. Aoki et al. describes treating the resist surface hardened layer 9 with a hydrogen/nitrogen plasma to convert the resist surface hardened layer 9 to a property-changed resist hardened layer 9A, which can be removed by a resist mover liquid. *Id.* at column 9, lines 16-33.

As a portion of the copper film 3 is exposed in the through-hole 7 when the resist surface hardened layer 9 is treated with a hydrogen/nitrogen plasma, Applicants admit that Aoki et al. inherently describes exposing the copper film 3 to a reducing plasma. Applicants respectfully assert, however, that Aoki et al. does not describe exposing at least a portion of the copper film 3 to an oxidizing agent that causes an oxidation injury to the copper film 3, and exposing the copper film 3 to a reducing plasma to at least partly reverse the oxidation injury. On the contrary, Aoki et al. describes that “in place of the prior art resist removal by the oxygen plasma ashing, the resist is removed by a combination of the hydrogen/nitrogen plasma treatment and the wet treatment using the resist remover liquid. As a result, the resist film and the deposits can be removed while preventing the oxidation of the copper film 3.” *Id.* at column 9, lines 58-64.

The Examiner asserts at page 2 of the outstanding Office Action that “Aoki discloses, in figure 9, that the copper does experience oxidation injury.” Applicants respectfully disagree. Aoki et al. specifically states, describing what Figure 9 discloses, that “by using the hydrogen/nitrogen plasma treatment, the oxidation of copper can be remarkably prevented.” *Id.* at column 10, lines 19-22. In other words, Aoki et al. expressly states that Figure 9 discloses that formation of copper oxide is prevented by employing the hydrogen/nitrogen plasma treatment.

Figure 9 does show an extremely thin layer of copper oxide on the outer surface of a sample of copper film as measured by an X-ray photoelectron spectroscope (XPS). This, however, clearly is not evidence that an oxidation injury was caused by an oxidizing agent and at least partly reversed by exposing the metallic layer to a reducing plasma. In contrast, it merely is evidence that an extremely thin layer of copper oxide was formed on the copper film sometime prior to or during analysis using the XPS.

Aoki et al. expressly states numerous times that, when performed, the invention prevents the oxidation of the copper film 3. *Id.* at column 4, lines 51-52, 55-56; column 6, lines 57-58; column 9, lines 62-64; column 10 lines 1-2, 19-22; column 12, lines 1-2. Thus, the most reasonable explanation for the presence of the thin layer of copper oxide that is consistent with

the rest of the disclosure is that the oxidation occurred after the reducing plasma treatment described by Aoki et al. (e.g. the samples may have been exposed to air (which includes oxygen) when the samples were transferred from a plasma chamber to the XPS for analysis). *See id.* at column 10, lines 10-23. There is no evidence whatsoever that the thin layer of copper oxide (or any other feature or structure that might be considered to be an oxidation injury) is exposed to a reducing plasma to at least partly reverse any oxidation or oxidation injury.

On page 3 of the outstanding Office Action, the Examiner asserts that column 6, lines 46-67 of Aoki et al. disclose that the reducing plasma at least partly reverses the oxidation injury. Applicants respectfully disagree. These lines of Aoki et al. disclose that the non-oxidizing gas is a reducing gas and that the non-oxidizing gas removes “the resist film and the resist surface hardened layer while preventing oxidation of the easily oxidizable film.” *Aoki et al.*, column 6, lines 55-58. The resist film 6 and the resist surface hardened layer 9, however, are not an oxidation injury to the copper film 3 (as seen in FIG. 7B, the surface hardened layer 9 does not form on the copper film 3). The only film or layer that Aoki et al. discloses forming on the copper film 3 is the etching residue 8, “which is a reaction product of the etching gas and the copper film 3.” *Id.* at column 9, lines 11-13. However, as shown by FIG. 7C of Aoki et al., the etching residue 8 is not “at least partly reversed” by the hydrogen/nitrogen plasma. In contrast, Aoki et al. describes the etching residue 8 being removed by a resist remover liquid. *Id.* at column 9, lines 44-47; FIG. 7D.

In view of the above, Aoki et al. clearly does not expressly or inherently describe all the limitations of independent claim 1. Therefore, Applicants respectfully assert that claim 1 is not anticipated by Aoki et al. and request that the Examiner withdraw the rejection of independent claim 1 under 35 U.S.C. § 102(b).

Applicants additionally assert that each of dependent claims 2 through 16, 20, 22, 24, and 25 is allowable, among other reasons, because each depends either directly or indirectly from independent claim 1, which is allowable. Therefore, Applicants request that the Examiner withdraw the 35 U.S.C. § 102(b) rejection to claims 2 through 16, 20, 22, 24, and 25, in addition to the rejection of independent claim 1.

Regarding claims 8 and 9, Applicants additionally assert that Aoki et al. does not describe causing an oxidation injury that comprises formation of copper oxide, or reversing the oxidation

injury by reducing the copper oxide to copper. As previously discussed, Aoki *et al.* specifically describes that the copper film 3 suffers “no damage” and that the oxidation of the copper film 3 is “prevented.” *Id.* at column 4, line 51 and 55, column 10, lines 20-22. Although Aoki *et al.* shows a thin layer of copper oxide on the surface of a sample layer of copper, this oxide was clearly not formed before exposing the reducing plasma treatment, and Aoki *et al.* does not expressly or inherently describe exposing this copper oxide to a reducing plasma to at least partly reverse any oxidation injury. Therefore, Applicants respectfully assert that dependent claims 8 and 9 are not anticipated by Aoki *et al.* and request that the Examiner withdraw the rejection of independent claim 1 under 35 U.S.C. § 102(b) for this additional reason.

Regarding claim 10 through 12, Applicants additionally assert that Aoki *et al.* does not describe “forming a metallic plug that passes through” “a first intermetal insulating layer,” a “second intermetal insulating layer,” “a third intermetal insulating layer,” or a “plurality of intermetal insulating layers,” as recited in dependent claims 10 through 12. Aoki *et al.* merely describes a plug 22 that passes through a single HSQ film 5. *See Aoki et al.*, FIGS. 7F and 8H. The Examiner asserts at page 4 of the outstanding Office Action that “it is understood that the processes of figures 7A-7F may be implemented for a dual or triple damascene structure,” and that “figures 7A-7F show damascene structures which include a plurality of damascene levels.” Applicants respectfully disagree and request that the Examiner cite to a specific description or teaching in Aoki *et al.* relating to a dual or triple damascene structure. Applicants respectfully assert that the damascene structures shown in Figures 7A-7F are merely single damascene structures, as only a plug 22 passes through one HSQ film 5, as shown in FIGS. 7F. Therefore, Applicants respectfully assert that each of the dependent claims 10, 11, and 12 is not anticipated by Aoki *et al.* and request that the Examiner withdraw the rejection of dependent claims 10 through 12 under 35 U.S.C. § 102(b) for this additional reason.

In regards to claims 13 through 15, the Examiner asserts at page 3 of the outstanding Office Action that “figures 7A-7F makes [sic] it clear that the reducing plasma process and the formation of the damascene opening occur in the same environment or chamber.” Applicants respectfully disagree and assert that figures 7A-7F merely illustrate particular structures. Figures 7A-7F of Aoki *et al.* in no way illustrate or indicate the environment or enclosure in which the structures shown therein are formed. Aoki *et al.* teaches that the HSQ film 5 and the

silicon nitride film 4 are dry-etched to form the through-hole 7, but no description of the environment or chamber in which the dry-etching is performed is provided. *Aoki et al.*, column 9, lines 6-15. *Aoki et al.* further teaches that an electron cyclotron resonance plasma machine may be used to treat the resist surface hardened layer 9 with a hydrogen/nitrogen plasma. *Id.* at column 9, lines 16-33. *Aoki et al.* does not teach, however, dry-etching the through hole 7 in the electron resonance plasma machine that was used for the hydrogen/nitrogen plasma treatment. Therefore, Applicants respectfully assert that each of dependent claims 13, 14, and 15 are not anticipated by *Aoki et al.* and request that the Examiner withdraw the rejections of dependent claims 13 through 15 under 35 U.S.C. § 102(b) for this additional reason.

35 U.S.C. § 103(a) Obviousness Rejections

Obviousness Rejection Based on U.S. Patent No. 6,465,352 to Aoki et al.

Claims 17 and 18 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Aoki et al.* (U.S. Patent No. 6,465,352). Applicants respectfully traverse this rejection, as hereinafter set forth.

To establish a *prima facie* case of obviousness the prior art reference (or references when combined) must teach or suggest all the claim limitations. *In re Royka*, 490 F.2d 981, 985 (CCPA 1974); *see also* MPEP § 2143.03. Additionally, there must be “a reason that would have prompted a person of ordinary skill in the relevant field to combine the [prior art] elements” in the manner claimed. *KSR Int’l Co. v. Teleflex Inc.*, No. 04–1350, slip op. at 5 (U.S. April 30, 2007). Finally, to establish a *prima facie* case of obviousness there must be a reasonable expectation of success. *In re Merck & Co., Inc.*, 800 F.2d 1091, 1097 (Fed. Cir. 1986).

Dependent claims 17 and 18 depend from independent claim 1 and include all of the elements and limitations recited therein. The 35 U.S.C. § 103(a) obviousness rejections of claims 17 and 18 are improper because *Aoki et al.* does not teach or suggest “exposing at least a portion of the metallic layer to an oxidizing agent, the oxidizing agent causing an oxidation injury to the at least a portion of the metallic layer,” and “exposing the metallic layer to a reducing plasma to at least partly reverse the oxidation injury,” as recited in independent claim 1.

As previously discussed in relation to independent claim 1, *Aoki et al.* does not describe, teach, or suggest the limitations of independent claim 1 recited above. In contrast, *Aoki et al.*

specifically teaches multiple times that the disclosed invention prevents the oxidation of the copper film 3. *Aoki et al.*, column 6, lines 57-58; column 9, lines 62-64; column 10 lines 1-2, 19-22; column 12, lines 1-2. Thus, by teaching the use a silicon nitride film 4 “to prevent the oxidation of the copper film 3” and that “by using the hydrogen/nitrogen plasma treatment, the oxidation of copper can be remarkably prevented,” *Aoki et al.* teaches away from exposing at least a portion of the metallic layer to an oxidizing agent to cause an oxidation injury.

As *Aoki et al.* fails to teach or suggest each of the limitations of dependent claims 17 and 18, and in fact teaches away from the limitations of dependent claims 17 and 18, Applicants respectfully assert that dependent claims 17 and 18 would not have been obvious to one of ordinary skill in the art at the time the inventions were made considering *Aoki et al.*, and request that the Examiner withdraw the rejection of dependent claims 17 and 18 under 35 U.S.C. § 103(a).

Obviousness Rejection Based on U.S. Patent No. 6,465,352 to *Aoki et al.*

Claim 19 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over *Aoki et al.* (U.S. Patent No. 6,465,352). Applicants respectfully traverse this rejection, as hereinafter set forth.

Dependent claim 19 depends from independent claim 1 and includes all of the elements and limitations thereof. The 35 U.S.C. § 103(a) obviousness rejection of claim 19 is improper because, as previously discussed in relation to claim 1, *Aoki et al.* does not describe, teach, or suggest, and in fact teaches away from “exposing at least a portion of the metallic layer to an oxidizing agent, the oxidizing agent causing an oxidation injury to the at least a portion of the metallic layer,” and “exposing the metallic layer to a reducing plasma to at least partly reverse the oxidation injury,” as recited in independent claim 1.

As *Aoki et al.* fails to teach or suggest each of the limitations of dependent claim 19, and in fact teaches away from the limitations of dependent claim 19, Applicants respectfully assert that dependent claim 19 would not have been obvious to one of ordinary skill in the art at the time the invention was made considering *Aoki et al.*, and request that the Examiner withdraw the rejection of dependent claim 19 under 35 U.S.C. § 103(a).

Obviousness Rejection Based on U.S. Patent No. 6,465,352 to Aoki et al., in View of U.S. Patent Publication No. 2001/0034127 to Yamasaki et al.

Claim 21 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Aoki et al. (U.S. Patent No. 6,465,352), in view of Yamasaki et al. (U.S. Patent Publication No. 2001/0034127). Applicants respectfully traverse this rejection, as hereinafter set forth.

The 35 U.S.C. § 103(a) obviousness rejection of claim 21 is improper because none of the cited prior art references relied upon by the Examiner teach or suggest all of the limitations of claim 21.

Claim 21 depends from independent claim 1 and includes all of the elements and limitations recited therein. As previously discussed herein, Aoki et al. does not describe, teach, or suggest “exposing at least a portion of the metallic layer to an oxidizing agent, the oxidizing agent causing an oxidation injury to the at least a portion of the metallic layer,” and “exposing the metallic layer to a reducing plasma to at least partly reverse the oxidation injury,” as recited in independent claim.

The teachings of Yamasaki et al. do not satisfy the deficiencies. Yamasaki et al. teaches the use of tungsten nitride as a diffusion barrier in a damascene structure. *Yamasaki et al.*, page 1, paragraphs [0007] - [0012]. Yamasaki et al. does not, however, teach or suggest “exposing at least a portion of the metallic layer to an oxidizing agent, the oxidizing agent causing an oxidation injury to the at least a portion of the metallic layer,” and “exposing the metallic layer to a reducing plasma to at least partly reverse the oxidation injury,” as recited in independent claim 1.

As Aoki et al. and Yamasaki et al., when combined, do not teach or suggest each of the limitations of dependent claim 21, Applicants respectfully assert that dependent claim 21 would not have been obvious to one of ordinary skill in the art at the time the invention was made considering Aoki et al. in view of Yamasaki et al., and request that the Examiner withdraw the rejection of dependent claim 21 under 35 U.S.C. § 103(a).

Obviousness Rejection Based on U.S. Patent No. 6,465,352 to Aoki et al., in View of U.S. Patent No. 6,270,353 to Andrews et al.

Claim 23 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Aoki et al. (U.S. Patent No. 6,465,352), in view of Andrews et al. (U.S. Patent No. 6,270,353). Applicants respectfully traverse this rejection, as hereinafter set forth.

The 35 U.S.C. § 103(a) obviousness rejection of claim 23 is improper because none of the cited prior art references relied upon by the Examiner teach or suggest all of the limitations of claim 23.

Claim 23 depends from independent claim 1 and includes all of the elements and limitations recited therein. As previously discussed herein, Aoki et al. does not describe, teach, or suggest “exposing at least a portion of the metallic layer to an oxidizing agent, the oxidizing agent causing an oxidation injury to the at least a portion of the metallic layer,” and “exposing the metallic layer to a reducing plasma to at least partly reverse the oxidation injury,” as recited in independent claim 1.

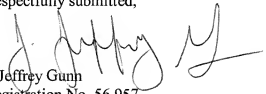
The teachings of Andrews et al. do not satisfy the deficiencies. Andrews et al. teaches a method of forming a shallow trench isolation (STI) region on an integrated circuit using non-conformal dielectric material. *Andrews et al.*, column 2, lines 37-39. Andrews et al. teaches that a photo resist may be used in forming the STI region, and that a hydrofluoric-acid containing wet-etch can be used to etch away a high density plasma oxide. *Id.* at column 3, line 62 – column 4, line 9. Andrews et al. does not, however, teach or suggest “exposing at least a portion of the metallic layer to an oxidizing agent, the oxidizing agent causing an oxidation injury to the at least a portion of the metallic layer,” and “exposing the metallic layer to a reducing plasma to at least partly reverse the oxidation injury,” as recited in independent claim 1. Furthermore, Andrews et al. does not teach or suggest applying a wet cleaning process employing aqueous dilute hydrofluoric acid to a damascene structure, as recited independent claim 1.

As Aoki et al. and Andrews et al., when combined, do not teach or suggest each of the limitations of dependent claim 23, Applicants respectfully assert that dependent claim 23 would not have been obvious to one of ordinary skill in the art at the time the invention was made considering Aoki et al. in view of Andrews et al., and request that the Examiner withdraw the rejection of dependent claim 23 under 35 U.S.C. § 103(a).

CONCLUSION

Claims 1 through 25 are believed to be in condition for allowance, and an early notice thereof is respectfully solicited. Should the Examiner determine that additional issues remain which might be resolved by a telephone conference, he is respectfully invited to contact Applicants' undersigned attorney.

Respectfully submitted,



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